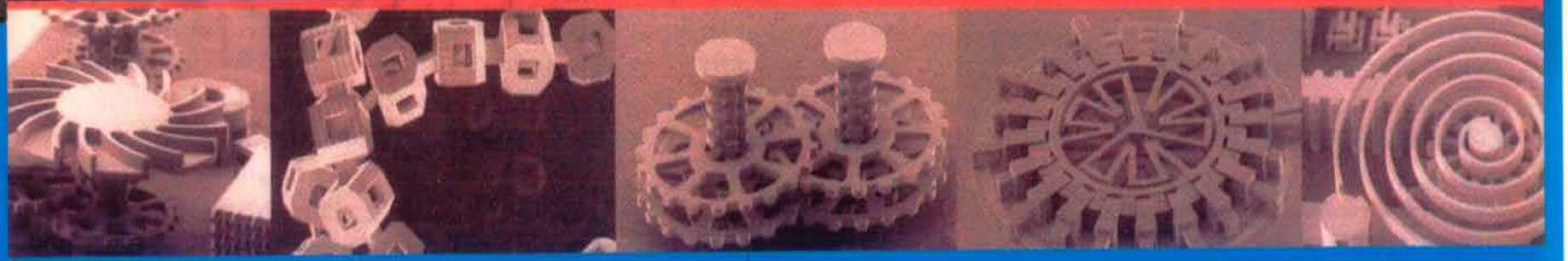
16957 RC

MEMS and Nanotechnology Workshop



An Emerging Army Technology

Presented to PM Stryker Feb 8th, 2007

Dr. Tom Meitzler, TARDEC

Speaker Topics

Oak Ridge National Labs ~ Image Fusion on a MEMS
University of Michigan ~ MEMS Fabrication Labs
Wayne State University ~ MEMS, Nanotechnology and Nano Optics

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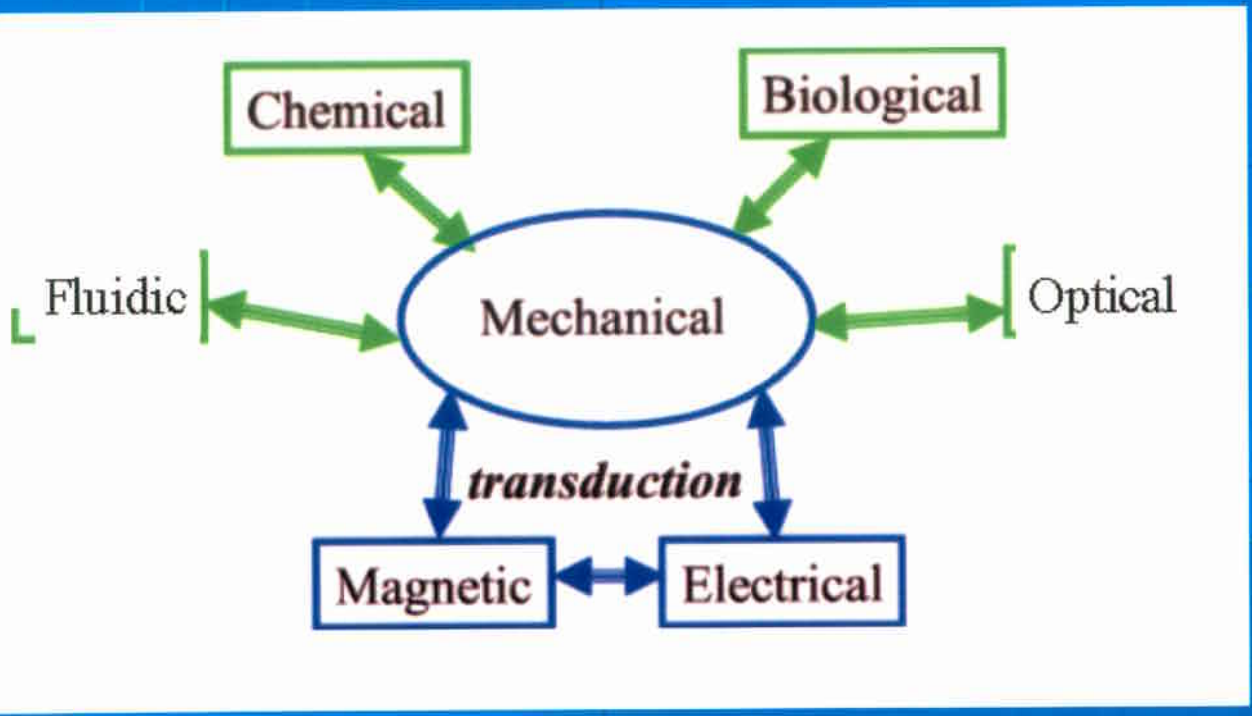
Definition of MEMS

MEMS: Micro-electro-mechanical system: Different physical domains within a miniaturized system



From MEMS to MEMS technology

SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

- Microelectronics fabrication technology extended to add mechanical degrees of freedom to the device

MICROMACHINING:

the use of lithographic and other microfabrication techniques to create miniaturized sensors, actuators and mechanical structures

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Micromachining technology

SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

- **What was behind the success of microelectronics is relevant to MEMS:**

1. Silicon is abundant, inexpensive, and can be produced and processed controllably with high standards of purity and perfection.

2. Silicon processing is based on thin film deposition, suitable for miniaturization.

3. Shape definition through lithography is capable of high precision and suitable for miniaturization.

4. Silicon is batch fabrication compatible: cost reduction can be applied according to market demands.

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Some commercial applications of MEMS

SUPERIOR **TECHNOLOGY** FOR A SUPERIOR **ARMY**

- The rapid evolution of the MEMS world makes it difficult to track all emerging commercial applications. Typical established mass-produced examples are:
  - *Accelerometers* for airbag systems
  - Heads for *ink jet printers* and hard disk drivers
  - Optical *micro mirrors* for *image projectors*
  - *Pressure* and *chemical* sensors for medical applications
  - Quartz watch *crystal* resonators for time-keeping

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MEMS applications by industry

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Defense	Medical	Electronics	Communications	Automotive
Munitions Guidance	Blood Pressure Sensor	Disk drive heads	Optical or Photonic Switches and cross-connects in Broadband networks	Internal Navigation sensors
Surveillance	Muscle stimulators & drug delivery systems	Inkjet Printer heads	RF Relays, Switches, and Filters	Air conditioning compressor sensor
Arming Systems	Implanted Pressure sensors	Projection Screen Televisions	Projection displays in portable communications devices and instrumentation	Brake force sensors & Suspension control accelerometers
Embedded Sensors	Prosthetics	Earthquake Sensors	Voltage controlled oscillators (VCOs)	Fuel level and vapor pressure sensors
Data Storage	Miniature analytical instruments	Avionics Pressure sensors	Splitters and couplers	Airbag sensors
Aircraft Control	Pacemakers	Mass Data Storage Systems	Tunable lasers	"Intelligent" Tires

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SUPE

Absorption of fumes emissions

Sensors
- Actuate active suspension
- Position / motion
- Condition

ID tag

Biometric key

Mini radar / μ radar

360 vision IR mini camera

Vertical micro rocket launcher

Nanocoated bearings

Micro fuel cell with electric propulsion

Micro hybrid combustion / hydrogen motor

Flexible lightweight skirts with nano-armor

Radar absorption

Adaptive camouflage smart skin

Large LCD command screen

Ammo with sensors

Smaller high impact caliber gun

Super penetration

Or no barrel but micro cruise missles

Lightweight nano-armor

Nano rheo fluid structure in armor

Thermal suppression

Landvehicle

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SUPERIOR TECHNO

Sensor	Phenomenology	Strengths	Comments
Metal Detector	Maps metal content of soil	• Metal mines • Surface/shallow emplacement	• Time domain / frequency analysis improves probability of discrimination
Ground Penetrating Radar (real aperture)	Measures return from dielectric discontinuities	• Metallic mines • Nonmetallic mines with dielectric discontinuity	• Complex natural scenarios provides technical basis to improve discrimination
Ultra Wideband SAR (at low frequency)	Images reflected radar returns	• Shape-based mine/clutter discrimination • Metallic mines	• SAR processing needed to achieve adequate resolution for airborne surveys
Visible Imagery	Different reflectivity vs λ	• Surface mines on locally uniform background • Daylight • Shape-based discrimination	
Thermal IR Imagery	Temperature difference between mine & background, differences in heating/cooling rates	• Surface mines • Buried mines • Wet soil • Shape-based discrimination • Functions at night	
Multi- or hyper-spectral Imagery	Spectral difference between mine and background	• Surface mines in cluttered background • Disturbed earth	
Active Laser Polarization Imagery	Mine depolarizes incident radiation differently than clutter	• Surface mines • Freshly buried mines • Functions at night	
Passive MMW	Temperature difference between mine & background	• Damp weather	
Neutron Activation Analysis	Detects chemicals associated with explosives based on their behavior when exposed to radiation	• Shallow-buried nonmetallic mines	• May be effective in confirming cues that are marginally detected
Nuclear Quadrupole Resonance	Detects explosive contents of mine	• Suppresses false alarms by finding explosives	• Not suited for wide area search – needs companion detector

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Night Vision (IR) and Visual Image Fusion in Real-Time

SUPERIOR **TECHNOLOGY** FOR A SUPERIOR **ARMY**

Visible image shows:

- Road edges
- Sign

Infrared image shows:

-Person

-Road beyond headlights

But only infrared image fused with visible light image show all features

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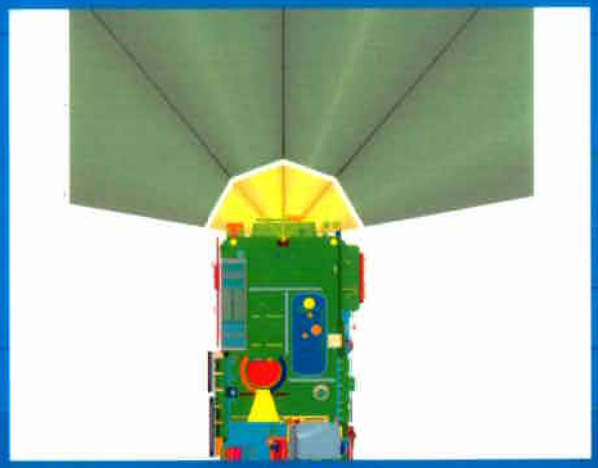
Navigator Prototype Kit

SUPERIOR **TECHNOLOGY** FOR A SUPERIOR **ARMY**

Fully Passive 360° Image Fusion Technology for Homeland Defense with Modular Camera Kit



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Present Version of System

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Rugged version

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Optical MEMS and Imaging Arrays

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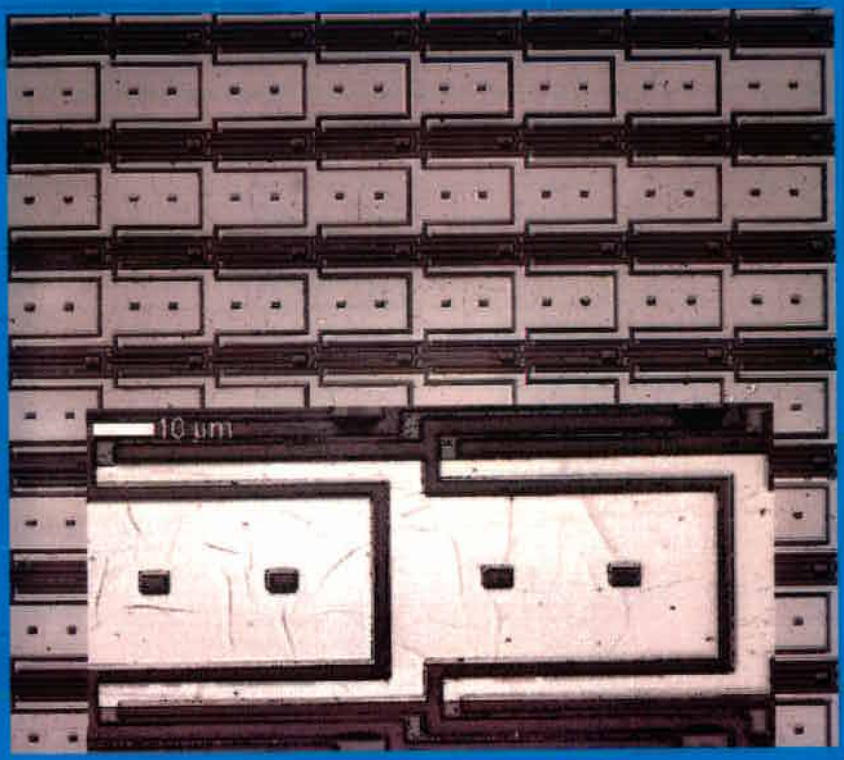

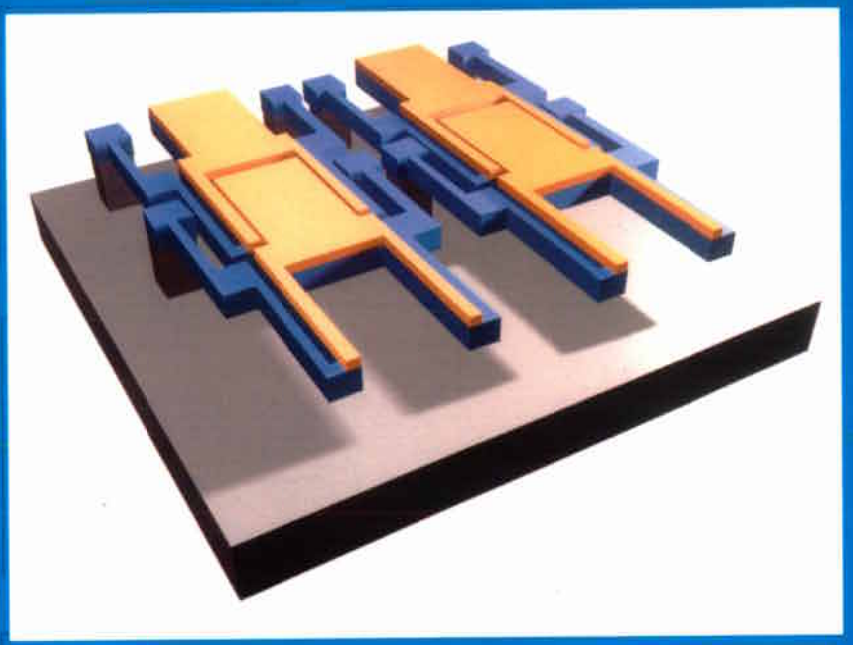

Photos courtesy of Dr. Datskos, Oak Ridge National Laboratory

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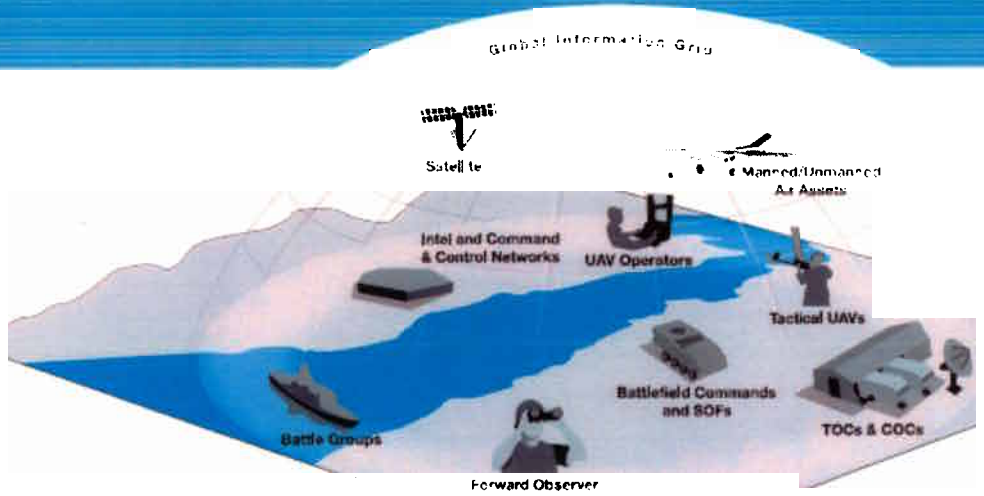
SUPERIOR TECHNOLOGY FO

Ground Mobility Vehicles

HWMMV users installed the integrated VideoScout-Rover III 300 receiver to capture locally launched UAV video, as well as vehicle mounted EO-IR sensor systems. Incoming video can be paused and rewound for immediate analysis, and even streamed to other vehicles in the convoy in real-time, and annotated, recorded and indexed for subsequent search and review.

Capture, record, transmit



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Fusion of Multiple MEMS Sensor Suite Data

SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

- MEMS Sensors integrated into suite along with power, communication and control
- Multiple integrated suites placed around vehicle
- Integrated Suites communicate with "router' which transmits information through vehicle "hull"
- Powerful vehicle computer "fuses" data from many sensors and provides a "picture" of the world all around.
- Vehicle communication allows sharing of multi sensor suite data throughout entire C3 Network

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Applications of Nanotechnology and MEMS for Homeland Security

SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

The use of electronic-based sensors, built on MEMS and nanotechnologies, which work at the atomic, molecular levels, show promise for improvements in sensitivity, selectivity, improved detection rates, size and cost.

- Applications include: trace vapor explosive detection (electronic noses), radioactive material detection, image fusion, biological threat detection.
- Partners: Universities, government MEMS and Nanotechnology labs
- Survivability involvement : direction of academic programs on MEMS modeling and applications testing , storehouse of system information and applications.

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Workshop Program

SUPERIOR **TECHNOLOGY** FOR A SUPERIOR **ARMY**

Speaker 1:	Introduction to MEMS and Army Applications: Dr. Tom Meitzler, TARDEC
Speaker 2:	Prof. Sandrine Martin, MEMS and Nano fabrication, Univ. of Michigan
Speaker 3:	Dr. Panos Datskos, MOEMS, Oak Ridge Labs
Speaker 4:	Prof. Greg Auner, Current Research, Wayne State Univ.
Speaker 5:	Prof. Yang Zhao, Nano Optics, Wayne State Univ.

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